Panel Structure

The present invention relates to panel structures and their formation.

In accordance with the present invention, there is provided a panel structure comprising two sheets which are spaced apart to provide a void between, and are tied together by a plurality of tie means extending from one of the sheets to the other, the tie means being formed of substantially the same material as the sheets, and the sheets and the tie means forming an uninterrupted body of the material, the tie means being arranged to leave unobstructed voids within the plane of the panel, and there being an elongate reinforcing member located within at least one of the voids.

The ties are preferably arranged across the sheets in a geometric lattice. The void between the sheets may contain material different to the sheets, such as an expanded material.

The said material of the sheets and tie means may be a thermosetting or thermoplastic plastics material, other polymer material, metal, or board. The material of the sheet may incorporate reinforcing fibres.

The sheets are preferably generally planar and preferably generally parallel.

The tie means may each consist of material of one or more sheets, deformed out of the plane of the corresponding sheet and fused to material of the other sheet. Preferably material of both sheets is deformed from the respective plane to be fused with material of the other sheet at a position between the sheets. Preferably, the material of the sheets is fused midway between the sheets.

The material may be deformed by a process which includes the application of heat and/or pressure. The material may be deformed to form hollow projections toward the other sheet. Alternatively, the material may be deformed to form solid projections toward the other sheet. The projections may be formed with pointed, rounded or flat peaks for fusion with corresponding peaks formed from the other sheet.

Preferably no more than one half of the area of the sheets is deformed to form tie means. The sheets are preferably substantially planar between areas of deformation. The sheets may be deformed only at points, being substantially undeformed therebetween.

Various embodiments of the present invention will now be described in more detail, by way of example only, and with reference to the accompanying drawings in which:

Fig. 1a is a perspective view of a panel structure in accordance with a first embodiment of the invention, shown partly cut away;

Fig. 1b is a section along the line B-B of Fig. 1a and Fig. 1c is an enlarged view of part of Fig. 1b;

Figs. 2a, 2b and 2c correspond with Figs. 1a, 1b and 1c respectively, illustrating a second embodiment;

Figs. 3a, 3b and 3c correspond with Figs. 1a, 1b and 1c respectively, illustrating a third embodiment;

Fig. 4 is a section through a fourth embodiment of panel structure;

Figs. 5a and 5b illustrate the panel faces of the first and fourth embodiments;

Fig. 6, Figs. 7a and 7b illustrate various methods and arrangements for forming panel structures in accordance with the invention; and

Figs. 8a and 8b illustrate further methods and arrangements for forming panel structures in accordance with the invention.

Fig. 1 shows a panel structure 10 formed from two sheets 12. The sheets 12 are spaced apart to provide a void 13 between them. The sheets 12 are tied together at various positions by tie means indicated generally by the numeral 14. The ties 14 extend from one of the sheets 12 to the other.

As will be described, the ties 14 are formed of substantially the same material as the sheets 12 and in such a way that the sheets 12 and the tie means 14 form an uninterrupted body of material. The tie means 14 are arranged to leave unobstructed voids within the plane of the panel. An elongate reinforcing member 15 is located within at least one of the voids.

Each sheet 12 is generally planar except in the region of each tie 14. At these positions, the material of the sheet 12 is deformed from the plane of the sheet 12, in a manner to be described, to form a projection 16 toward the other sheet 12. The projections 16 are hollow. The projections 16 meet corresponding projections from the other sheet 12 at a plane indicated in Figs. 1b and 1c by a broken line 17. A solid line is not used because the material of the projections 16 is fused at this location, as part of the forming process, in order to form a single uninterrupted body of material across the sheets 12 and through the ties 14.

The sheets 12 may be formed of a thermosetting or thermoplastic plastics material, a polymer material, a metal alloy, or a paper board etc. for example. The material may optionally incorporate reinforcing fibres indicated at 18.

It can be seen from Figs. 1a to 1c that in this embodiment, the projections 16 have generally flat peaks prior to fusion, so that fusion takes place across the whole of the area of the peak.

The void 15, which is defined between the sheets 12, contains reinforcing members 15, and may otherwise be left unfilled, as an open void (as shown toward the left of Fig. 1b) or may contain a foam material 22 (as shown toward the right of Fig. 1b). The foam material is not necessarily required for the structural performance of the panel 10, but may be incorporated for other reasons, such as thermal or sound insulation. The reinforcing members 15 are preferably substantially rigid and of sufficient size to bear against the sheets 12, to provide strength against distortion of the panel. Thus, the panel is strengthened by the presence of the reinforcing members. The reinforcing members may be of metal or other material, and may be solid or hollow, the latter allowing the reinforcing member to be used as a service duct.

The reinforcing members may be straight, extending across the whole of the panel, or joints may be formed within the panel, such as is illustrated at 19. In a further alternative, the reinforcing members may be bent, rather than straight.

A second embodiment is shown in Figs. 2a to 2c. Features corresponding with those of Fig. 1 are given corresponding reference numerals, suffixed a.

In the second embodiment, the panel 10a again comprises two sheets 12a connected by tie means 14a formed by projections 16a. Reinforcing members 15a are provided in the voids 13a left between the projections 16a. The difference between the first and second embodiments relates to the shape of the projections 16a. In the second embodiment, the projections 16a are conical, with pointed peaks, so that the area of intimate contact and fusion between the projections 16a is relatively small in the second embodiment, in comparison with the area provided by the flat peaks of the projections 16.

Fusion of the peaks results in a single uninterrupted body of material across the sheets 12a and through the ties 14a.

Again, the sheets 12a are preferably a thermosetting or thermoplastic plastics material, other polymer material, a metal or a board etc., and may incorporate reinforcing fibres (not shown in Fig. 2). The space 20a may be left as an open void, or filled with foam (not shown in Fig. 2).

Figs. 3a to 3c show a third embodiment of panel structure 10b. Again, like reference numerals are used for corresponding features, with the suffix b.

In this third embodiment, the sheets 12b are tied by tie means 14b in the form of conical, pointed and solid projections 16b. Thus, the main difference between the third embodiment and the first two embodiments is that the projections 16b are solid rather than hollow. Thermosetting or thermoplastic plastics material, another polymer material, a metal or a board etc. is again preferably used, and may optionally incorporate reinforcing fibres. The void 13b contains reinforcing members 15b in the unobstructed voids between tie means 14b, and may otherwise be an open void or foam-filled.

Fusion of the peaks results in a single uninterrupted body of material across the sheets 12b and through the ties 14b.

A fourth embodiment of panel structure 10c is illustrated in section in Fig. 4, again using like numerals and the suffix c.

In the panel 10c, the sheets 12c are planar across almost their entire area. The ties 14c are in the form of thin spindles 16c of material, forming spaced columns extending substantially perpendicular to the sheets 12c. Again, the sheets 12c and ties 14c are preferably formed of thermosetting or thermoplastic plastics material, a polymer material, a metal alloy, or a paper board etc. with optional reinforcing fibres. The sheets 12c and spindles 16c together form a single uninterrupted body of material. The void 13c is in the form of a series of parallel, straight unobstructed voids running across the entire width of the panel. At least some of the voids 13c contain reinforcing members 15c.

Figs. 5a and 5b show the outer faces of the first and fourth embodiments. In Fig. 5a, the hollow nature of the projections 16 results in visible concavities 26 at each projection location 28. The projection locations are arranged at the interstices of a geometric lattice, illustrated in this example as a square lattice 30, indicated by broken lines. The square size of the lattice 30, in comparison with the size of the concavities 26, results in the projections 16 being sufficiently widely spaced to leave unobstructed straight voids 13 to receive the reinforcing members 15, which extend within the plane of the panel 10, between the projections 16.

In the fourth embodiment, illustrated in Fig. 5b, the projections 16c are again arranged on a square lattice 30. However, the narrow and solid nature of the spindles 16c results in the exposed face of the panel 10c being wholly or virtually unaltered from a planar surface, even at the projection locations

28. For clarity, the locations of the spindles 16c are illustrated in Fig. 5b by means of small circles. It can again be seen, in common with the first embodiment, that the spacing of the spindles 16c leaves the voids 13c unobstructed and straight, allowing the reinforcing members 15c to extend in various directions through the plane of the panel 10c.

It can readily be seen from both Figs. 5a and 5b that the area between the projection locations 28 represents significantly more than one half of the total area of the sheets 12. That is to say, no more than one half of the area of the sheets 12 is deformed to form ties 14. In Fig. 5a, there is deformation to form the concavities 26, but these are sufficiently small to leave half, or more than one half of the area of the sheets undeformed, between projection locations 28. In the arrangement of Fig. 5b, as has been described, the columns 24 are sufficiently small that the outer face of the panel 10c is virtually undeformed by the formation of the spindles 16c.

Fig. 6 illustrates a first method for forming a panel structure in accordance with the invention. This first method is particularly appropriate for use with the first embodiment, but may also be used with the second embodiment. The method will be described in relation to the first embodiment.

The sheets 12 are first provided, preformed to have the projections 16. The sheets 12 are oriented so that the respective projections 16 each project towards the other sheet, and the sheets 12 are then brought together, around the reinforcing members 15. Thus, the peaks of the projections 16 come together in intimate contact and the reinforcing members 15 are placed in the voids 13, as they are formed. Alternatively, the reinforcing members may be introduced axially into the voids 13, from the edge of the panel. Heat is then applied to the peaks, for example by introducing sources of heat into the concavities 26, at the positions indicated by the arrows 34, resulting in the

material in the region of the projection peaks being heated and softened. This allows the material of the two sheets to be fused by melting, so that the material of the two sheets blends into a single whole. The result is illustrated particularly in Fig. 1c. It is this process of creating fusion between the sheets which makes it appropriate to use a broken line to indicate the two projections 16 in Fig. 1c, rather than a solid line. In practice, after the fusion has occurred, it ceases to be possible to identify the precise location of the boundary between the two projections which have fused. A single body of material has been formed from the fusion of the two bodies which were initially separate and distinct.

Figs. 7a and 7b illustrate a second method which may be used to form a panel structure.

In this method, two planar sheets of material 12 are brought together in intimate contact, both being planar at this stage. Heating is then applied at the projection locations, as indicated by arrows 36. This causes localised heating of the thermoplastic material of the sheets 12, so that the material of the two sheets fuses together at these locations.

After fusion has begun, but before the material has fully cooled, and thus while the material remains plastic, the sheets 12 are moved apart (Fig. 7b), causing ties 14 to begin to form by material being stretched between the sheets 12. The sheets 12 may be moved apart either by suction from outside the panel or by blowing air or other fluid between the sheets 12, forcing them apart.

As the separation continues, the ties 14 continue to form until their final form is reached. The sheets 12 are then maintained in this position until the material fully cools.

The process just described is particularly appropriate for forming the fourth embodiment, using localised heating to form columns connecting the sheets. The process can be modified when used to form the first and second embodiments, in two principal respects. First, secondary regions of heating, indicated by arrows 38, are applied as rings of heating around each projection location. The secondary heating at 38 is less than at the projection location, either being at a lower temperature, or for a shorter duration, so that the material around the ring is not softened sufficiently to fuse with the other sheet 12. Consequently, whereas the material at the projection location 28 fuses, material in the surrounding ring is merely softened. Consequently, as the sheets 12 are moved apart, the softened material of the rings 38 can stretch to form side walls 40 of the projections 16, 16A, but without fusing to material of the other sheet 12. This helps form projections of the type shown in the first and second embodiments, and may be further assisted by forcing the sheets 12 against a shaped mould tool or other former, as they move apart.

In this method, reinforcing members are introduced after the ties and voids have been formed.

Fig. 8 illustrates a technique in which the methods of Figs. 6 or 7 may be implemented as a continuous process. Sheets 12 are fed continuously from the left hand side of Fig. 8a toward the nip of rollers 42. The surface of one of the rollers 42 is illustrated on an enlarged scale in Fig. 8b. The roller 42 has lines of suction apertures 44 and lines of heating elements 46. Consequently, as the sheets 12 pass through the nip of the rollers 42, regions corresponding with the projection locations 28 are heated by the heating elements 46. As the sheets 12 leave the nip, suction though the apertures 44 tends to hold the sheets 12 against the rollers, so that the sheets 12 are held or pulled apart. Consequently, the locations 28 which have been heated and fused are then stretched to form ties, in the manner described in relation to Fig. 7b. Alternatively, the rollers 42 may have more complex surface form, to

allow reinforcing members to be fed between the sheets 12 as they pass through the nip of the rollers. Alternatively, the reinforcing members can be introduced from the panel edges, after the tie means have been fully formed. The roller 42 may be formed to accommodate sheets 12 which are preformed with projections 16 (for example by means of a previous step involving heated forming rollers), so that heat is applied at the peaks of the projections 16 (as illustrated in Fig. 6a) but without suction thereafter being required.

In all of the methods described above, the use of fusion between two panels of thermoplastic material allows a single, uninterrupted body of material to be formed, effectively without boundaries and thus, without structural weaknesses which boundaries create. They are further strengthened by the presence of the reinforcing members. The result is a panel structure in which two spaced apart panels are tied together and reinforced, so that their flexural or shear movement is restricted. (Shear movement is movement within their plane, relative to the other sheet). Shear movement would be required for any bending of the panel structure and thus, resistance to bending is provided by this resistance to shear movement and is further enhanced by the presence of the reinforcing members. The result is a structure in which the strength, for example strength against impact, is provided primarily by the sheets (which may be formed as thickly as is appropriate), but in which bending resistance is provided primarily by the manner of tying them together and reinforcing them. The presence of a void within the structure allows a rigid but lightweight structure to be created.

A rigid, lightweight panel structure of the type described can be used advantageously in the formation of motor homes, boats, buildings (especially temporary or portable buildings), formwork, decking, transportation packaging and platforms, vehicle bodies, window shutters and other applications. In many of these, it is advantageous that the undeformed outer surface of the sheets 12 forms at least 50% of the total surface area, so that additional

panels or sheet material, particularly covering applied for cosmetic reasons, can be applied with a good visual finish. Thus, the panel structure may be used as the wall of a transportable building or mobile home, and covered with a conventional wallpaper, without the form of the panel structure becoming apparent, particularly if the fourth embodiment is used.

Many variations and modifications may be made to the structures described above, without departing from the scope of the invention. In particular, a range of different materials could be used. Also, different means of achieving continuity in the ties may be used, such as exothermic fusion for thermosetting polymers or resin impregnated board. Dimensions and relative dimensions could be changed from those described.

The description has referred to two parallel sheets, tied together, but could be implemented with a greater number of sheets, or with sheets which are not precisely parallel. Also, curvatures and compound shapes may be created by modified layout of the ties and disposition of reinforcing members.

Whilst endeavouring in the foregoing specification to draw attention to those features of the invention believed to be of particular importance it should be understood that the Applicant claims protection in respect of any patentable feature or combination of features hereinbefore referred to and/or shown in the drawings whether or not particular emphasis has been placed thereon.